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EASTERN NUCLEAR SERVICES
SUPPLY SYSTEM PERFORMANCE MEASURES

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ABSTRACT

Eastern Nuclear Services will shortly be integrating the supply functions at Darlington and Pickering NGSs, and establishing performance measures for the new section. Operations Research was requested to interview station staff and evaluate current performance. Stockouts and Supply processing times were identified as the most important performance criteria. Our analysis indicates that it takes an average of 55 working days to turn an ISR into a delivered product, 30% of which arrive late. The frequency distributions of these functions are exponential. This means that it can take 165 days before 95% of the ordered stock arrives. Supply section should look for internal, administrative means of reducing the mean processing times.

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To

To: Dr. D. Mills
Director of Research

EASTERN NUCLEAR SERVICES
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1. INTRODUCTION

All aspects of the material supply functions of Pickering and Darlington Nuclear Generating Stations are managed by Eastern Nuclear Services (ENS). Once a supply request is received from stations, it is the responsibility of ENS to procure the material and store it on site. All warehouses are staffed by ENS personnel, and all material requirements and supply planning are also the responsibility of ENS.

Historically, the administrative aspects of the material supply function have been handled separately by ENS staff at each station. This includes the processing of internal supply requests (ISRs) , preparation of requisitions and purchase orders, and liaison with suppliers and Supply Division procurement staff.

The Production Branch productivity review has recommended that the supply functions of the two stations be centralized at one off site location. By doing so, expertise would be centralized, and the staff would work more efficiently. Once the systems are fully integrated, higher productivity and service levels would result as warehouse operations are optimized and duplicate stock codes eliminated.

The purpose of this project is to identify measures that can be used to assess the performance of the supply operation as it currently exists, and compare it to the post integration organization.

2. METHOD

The project was undertaken in two parts.

First, station staff were interviewed to establish their views as to what are good performance measures. All managers at both stations, all superintendents and some engineers who depend on the supply process were interviewed.

Next, issue lead times were established for both stations. This was done by analyzing the processing times for supply documents: internal supply requests, requisitions, and purchase orders.

3. THE INTERVIEWS

Twenty-one Managerial and M&P staff were interviewed at PNGS and DNGS. The discussions were generally open ended, but centred on four general questions. The questions, and a summary of the responses are discussed below. All text shown in italics are direct quotes.

3.1 What is you job function in relation to Supply?

Managers viewed the supply function from a more remote perspective than engineers did. As was expected, most of the detailed comments came from lower level staff.

3.2 What do you consider to be valid performance measures for the supply function?

A list of possible measures was quickly developed after the first couple of interviews. Everyone was canvassed as to preference. The frequency column in the following table summarizes the number of interviewees who thought that the suggested measure was a good idea.

Suggested Measure	Frequency	Suggested Value (if any)
Stores Stockout	9	5 %
Promised Delivery Date Not Met	8	0
Issue Lead Time	8	1 - 4 weeks
Receiving Backlog	3	7 days
Customer Satisfaction Survey	2	
Wesleyville Turnaround Time	1	24 Hours
Number of Expedites	1	
Lost Opportunity	1	
# Jobs on Hold	1	
Time Stamp Queue at Stores	1	

3.3 What do you expect from Supply?

Timeliness: the most important thing that Supply can do is get the material in on time and within specification. Supply should procure, store, care for and issue material when it is needed, not when it is convenient.

Courtesy: another common expectation is friendly and courteous service. There were many compliments for Supply on this point (*"Extremely good service"*), and no criticisms. But as one manager said, *"When you go to McDonalds, you always get courteous service. But if the meat is rotten, or they expect you to take home a year's supply of Big Mac's, you won't be happy, no matter how good the staff are."*

Close working relationship: station personnel, especially at Darlington, expect a close working relationship with Supply, and expect that to continue after the move.

Technical know how: a higher level of technical capability, knowledge, and experience from the staff would *"make life easier"* for station personnel. There were two views as to how to accomplish this: either upgrade the existing jobs, or add specialized technical staff. Quality Assurance is one area where

ENS could have more expertise.

Ownership: there is a strong feeling that once an ISR is signed, the originator should be in a carefree mode until the delivery date, assuming that the request is carefully prepared.

As the system currently operates, however, many engineers feel that too much of their time is lost on supply issues. Many technical follow up questions are asked that should be handled by Supply. When delivery dates are missed, especially without adequate warning, or unexpected stockouts occur, a lot of time can be wasted attempting to personally rectify the matter.

The stations would like to see ENS assume ownership of the entire supply function, including all problems, regardless of where they occur in the supply process. Although the stations are aware that a significant number of the problems are currently beyond ENS' control, they still expect them to find the solutions.

Status updates: many engineers would like to see ENS implement a status update system that would provide feedback to users on turnaround, quality, or lead time problems that may affect delivery targets.

Education: station personnel need to know how the supply process operates and what they can expect from Supply. Supply should issue a booklet similar to the Administrative Services Standards and Procedures 'Fast Facts', which includes performance measures and instructions for users. A series of presentations to station personnel on the use of their services would also be helpful. Both of these suggestions came out in the interviews.

3.4 What Supply should expect from you?

Planning: the stations should anticipate their needs and specify reasonable deadlines on ISRs.

Accuracy: ISRs should be completely, accurately, and clearly filled out. Any unusual requirements should be identified.

Independence: no interference in how Supply does its job. *"As long as they get it here on time, I don't care how they do it."*

Quick turnaround on ENS enquiries.

"ENS should tell us what their expectations are of us".

4. OTHER COMMENTS FROM THE INTERVIEWS

4.1 Comments on Performance Measures

Here are some highlights of the discussions of performance measures:

Stores Stockouts and **Missed Delivery Targets** are the measures most frequently and positively stated, and both relate to what station personnel expect from Supply: *"procure it, store it, take care of it, and issue it when needed".*

When an item is not in stock when required or not delivered on the deadline, that is when the supply system malfunction is most visible.

The only suggested value for stockouts was 5%, and by only one superintendent. *"It does not matter whether the service level is 95% or 99.8%, what is the impact of the stockouts that did occur?"*

ISR Turnaround Time from stamp date to when a purchase order is issued. This was the second most popular measure. Several suggestions were made:

- 2 days (mentioned twice)
- 1 week
- 2-3 weeks
- 6 weeks for routine off-the-shelf items (no exceptions), and 4 weeks plus vendor lead time for every thing else.

"There was a time when you could get anything routine in this plant in 6 weeks".

Only two caveats were mentioned about the use of this measure, and both are similar:

- It is an internal supply measure which is not as important as getting the material on time.
- *"Supply should be wary of setting up measures that make it look good when what's really important is meeting delivery deadlines".*

Lost Opportunity was a very interesting idea that came up in the interviews. ENS should have a system that could measure the time lost by station staff when an unexpected supply problem interrupts a job or forces an abort and reschedule process. A special charge number was suggested that could be used for time sheets. These lost costs could be used to set service level standards in the warehouse.

4.2 Other Comments

Being open-ended interviews, many comments were made about the supply function that were not specifically related to performance measures. These are included here with a view that they may be helpful for ENS management to improve their service.

Many managers feel that only one signature should suffice for a supply authorization. By the time a purchase requisition arrives for signature, he cannot remember the context in which the ISR was signed and must bring it up again with his staff. *"Why not eliminate the ISR?"*

"Supply is geared for what an item costs, not for what it's worth." This feeling was reflected in several interviews, where it was felt that cost should take a lower priority than timeliness and quality.

"Who do you talk to in Supply to solve a problem? It's a black hole, and that's where all ISRs end up."

"Supply should never run out of routine repairable items, such as bearings, valves, solenoids, and gaskets."

"Contaminated material is stores responsibility."

"It seems that (Head Office) Supply wants to control us, not serve us. What we want is service."

"No substitutions without authorization." Many engineers feel very strongly about buyers making unauthorized substitutions: parts that may appear similar may be incompatible from an engineering point of view.

5. THE DATA ANALYSIS

5.1 Average Processing Times

A performance measure that was frequently mentioned in the interviews was ISR turnaround times.

As this was anticipated by ENS management, a data file with the requisition and purchase order data was prepared for analysis from the Darlington and Pickering Work Management systems. All closed requisitions issued from January 1989 to July 1990 were processed.

As ISR stamp dates (the date when the ISR is received by Supply) are not electronically available, a random sample was taken from the filing systems. The ISR stamp date can be considered the starting point for total issue lead time.

	DNGS	PNGS
Number of requisitions analyzed	8187	9530
Number of ISRs sampled	148	107
Number of requisitions/day	21	24

Average Processing Times, working days:

Category	All	1	2	3	4	5	7
Darlington NGS							
ISR Processing	8	16	-	18	4	3	-
Requisition Approval	8	8	7	10	5	4	4
Purchase Order Processing	16	18	9	0	11	-	-
Delivery Time	22	22	15	22	18	-	-
Issue Lead Time	54	64	31	50	38	7	4
Pickering NGS							
ISR Processing	7	7	-	8	4	7	-
Requisition Approval	9	7	7	14	5	7	-
Purchase Order Processing	15	18	7	0	11	-	-
Delivery Time	24	25	17	27	22	-	-
Issue lead time	55	57	31	48	41	14	-

Categories
1: Head Office
2: Electronic transfer
3: Local purchase orders
4: Central Stores
5: Transfers
7: Contract/Repair

Dashes indicate either no sample was taken or available. A zero indicates that the indicated process does not apply. For instance, there are no purchase orders for type 3 (local) purchases. No type 7 (contract/repair) requisitions were available for Pickering, and no type 2 or 7 ISR data was available.

The ISR processing data, being a sample, is not as reliable as the requisition, purchase order or delivery time data, which was retrieved from the work management system and represents a 100% sample.

5.2 Issue Lead Times

Issue lead times are remarkably similar for the service functions for both stations, 54 days for Darlington and 55 for Pickering.

This was an unexpected outcome. Darlington is a pre-startup four-unit station with an on-site supply section, whereas Pickering is a mature eight-unit station with an off-site supply section. The interviews also revealed a higher degree of dissatisfaction at Pickering.

It appears then that the supply processing times are systematic, being dependent on the bureaucratic mechanisms involved and the fundamental nature of the service function: the procedures and documents used are similar for both stations, and the manpower allocations are approximately the same, or scaled appropriately.

It's surprising that local purchase order processing (category 3) is not much faster than shown, considering that one step of the process (the purchase order) is eliminated, and local supply staff are probably dealing with known local vendors.

Are these times reasonable? It's hard to say. The long durations could be due to the planning process, whereby personnel initiate ISRs with an eye to giving Supply plenty of procurement lead time. But if they are not reasonable, there are two ways that they can be decreased. Increase the staff or cut corners on the processes. Increasing staff is not an economically feasible alternative. Due to the nature of the curves, there is an inverse relationship between service time and number of servers: doubling supply manpower would only cut the mean time in half. Service time phenomena and the behaviour of queues are a well established field of Operations Research.

However, there are plenty of opportunities where time savings could be made by making administrative changes. Station personnel sense this and two suggestions came up in the interviews: simplify the signing authority system and eliminate ISRs. Automation will also play a hand, as more of the work management system goes on line. These are only a few suggestions.

5.3 The Shape of the Curves

In all cases, the density functions of the processing times are exponential (see attached figures), or members of the exponential family.

Exponential service time distributions are a common occurrence in service organizations, and it is important that ENS and their clients understand their characteristics. The standard deviation of an exponential distribution is equal to the mean. Thus, there can be a wide variation in processing times. The cumulative density function is $1-\exp(t/t_{AV})$. This means that three standard deviations are required

to set a performance standard that guarantees 95% completion.

Thus, if the mean processing time is 55 days, then ENS could only guarantee that 95% of the material would arrive in 165 days! Only 37% of the ISRs are turned around in less than the mean time (55 days).

The curves that appear to start at the origin and have a peak at some point greater then zero days are members of the exponential family called gamma distributions (Figures 1 and 2). They occur when a service being performed is actually a series of several underlying exponential mechanisms.

When you think about it, this is the case with the material procurement and supply process. Waiting for phone calls and approvals are all intermediate processes. Gamma functions can have even longer decay times.

Mean processing times can be reduced, but the shape of the curve will not change. Supply processing will always be exponential related, and three standard deviations will be required to guarantee 95% service. If station personnel were aware of this, would their feelings be as strong?

Notice that many of the curves exhibit weekly cycles (Figures 3, 4, 5). The only likely explanation for this is that most of the work is done on certain days of the week, or that future events are promised or recorded in weekly multiples.

A note on the Figure 1: as complete ISR data was not available, the "Total Processing Time" is not issue lead time, but only the elapsed time from requisition set up date to material receipt date. ISR processing time was not included because of the incompleteness of the samples.

5.4 Overdue Deliveries

Figure 8 shows the survival function of overdue deliveries. Thirty to thirty-three percent of all items arrive on site behind schedule and 5% are 9 weeks or more behind schedule. If ENS wanted to guarantee a date when 95% of deliveries arrive on site, it would be 9 weeks after the promised delivery date!

5.5 Other Analyses

Dollar value of purchase orders: a common assumption about purchase orders is that processing will take longer if the value of the order is high. But no correlation could be found between service time and purchase order value. A break down of purchase order values is shown in Figure 7.

Item count: no correlation could be found between the number of items listed on a purchase order and processing time.

Daily processing rates: some very unusual patterns were found in the weekday processing rates. Requisition and purchase order setups are highest on Mondays at Pickering, and Tuesdays at Darlington (Figures 9,10).

Daily Processing Rates

Document	Station	S	M	T	W	T	F	S
Requisition	DNGS	6	12	**69**	9	8	8	4
	PNGS	3	**74**	20	10	9	9	5
PO	DNGS	1	15	**35**	16	14	12	2
	PNGS	1	**29**	21	20	19	18	2

Promised delivery dates at both stations tend to fall on Mondays and Fridays, but actual delivery dates are spread evenly throughout the week.

6. DEFINITIONS

ISR processing time: the time difference between the ISR stamp date and the requisition setup date.

ISR stamp date: the date that the ISR is stamped, indicating that the ISR has been received by Supply.

ISR turnaround time: issue lead time.

Issue lead time: total time taken for the entire process, from ISR stamp date to material receipt date.

Material receipt date: the date the material was received, as entered on the work management system.

Purchase order in place date: the date on the purchase order.

Purchase order processing time: the difference between the requisition approval date and the purchase order in place date.

Requisition approval date: the date the requisition is approved.

Requisition approval time: the difference between the requisition setup date and the requisition approval date.

Requisition setup date: the date the requisition is setup, or first entered in the system.

Vendor delivery time: the vendor's lead time, the difference between the purchase order date and actual receipt of the material.

7. CONCLUSIONS

7.1 Station staff perceive stores stockouts, missed delivery dates, and ISR processing time to be the most appropriate performance measures.

7.2 Station staff expect timeliness, courtesy, close working relationships, technical expertise,

ownership, status updates, and training from Supply.

7.3 Supply can expect good planning, accuracy, independence, and responsiveness for the stations.

7.4 The issue lead times are similar for both stations, at 55 working days (11 weeks).

7.5 Thirty percent of all stock arrives late at DNGS and PNGS. Five percent have delays in excess of 9 weeks.

7.6 The density functions of the processing times are exponential. The standard deviation of exponential curves is equal to its mean value. This has implications for setting performance standards since it would require 3 standard deviations (165 days) before 95% of the ordered stock arrives.

7.7 Making station staff aware of this will be useful for planning purposes, and may help to alleviate some of the problems of dealing with the supply process.

7.8 With issue lead times as high as 55 days, there are strong incentives for finding administrative ways to reduce this.

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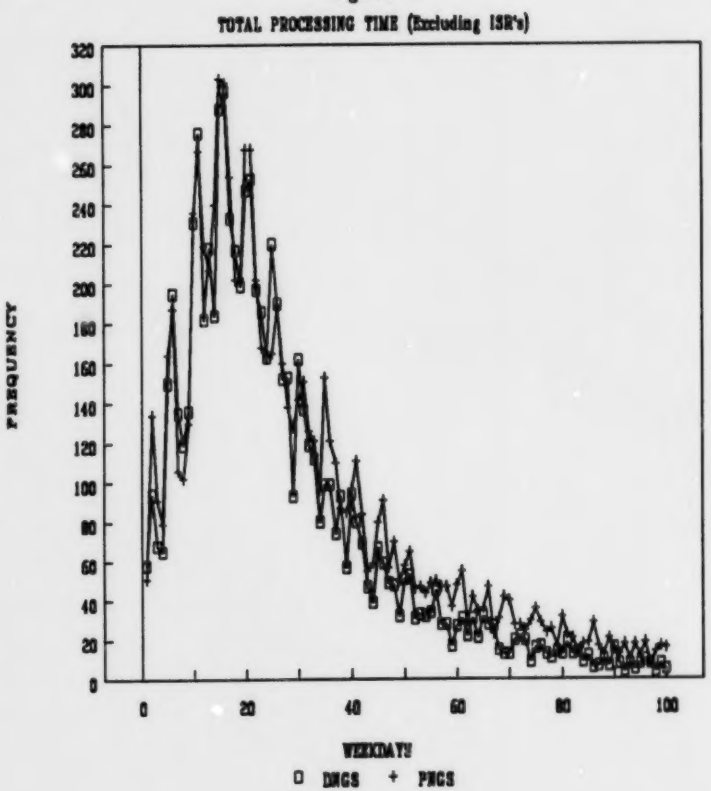
FIGURES

1. Figure 1 - Total Processing Time (Excluding ISRs)
2. Figure 2 - Requisition Approval Time
3. Figure 3 - Purchase Order Processing Time
4. Figure 4 - Vendor Delivery Time
5. Figure 5 - Receipt Date-Promised Delivery Date
6. Figure 6 - Overdue Deliveries
7. Figure 7 - Value of a Purchase Order
8. Figure 8 - Monthly Requisition Setups
9. Figure 9 - Weekday Patterns - Requisitions
10. Figure 10 - Weekday Patterns - Purchase Orders

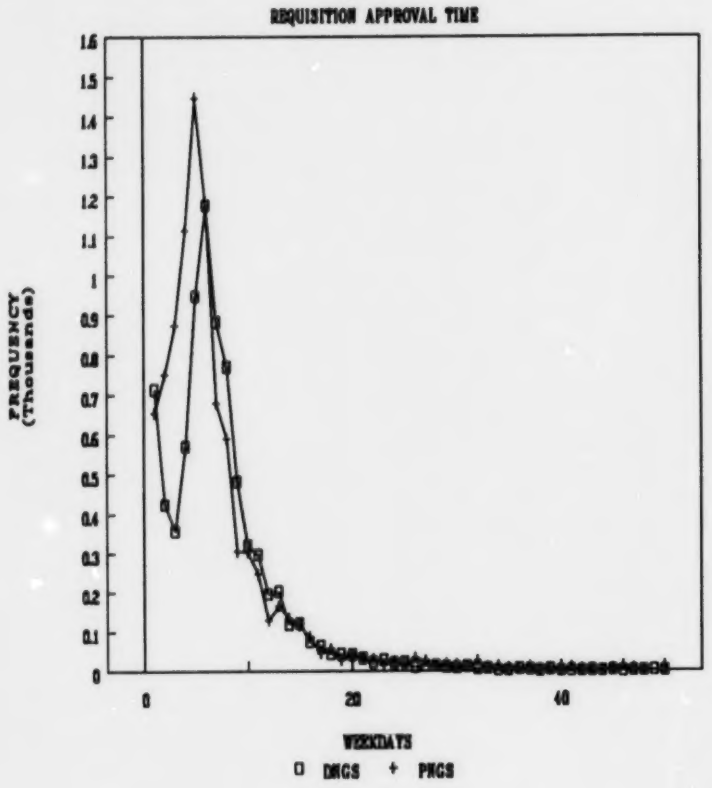
Figure 1



STATION	MEAN	STD DEV	VOLUME
DNGS	32	32	8104
PNGS	38	39	9409

Note: Elapsed time between requisition setup date and material receipt date. ISR data omitted (incomplete).

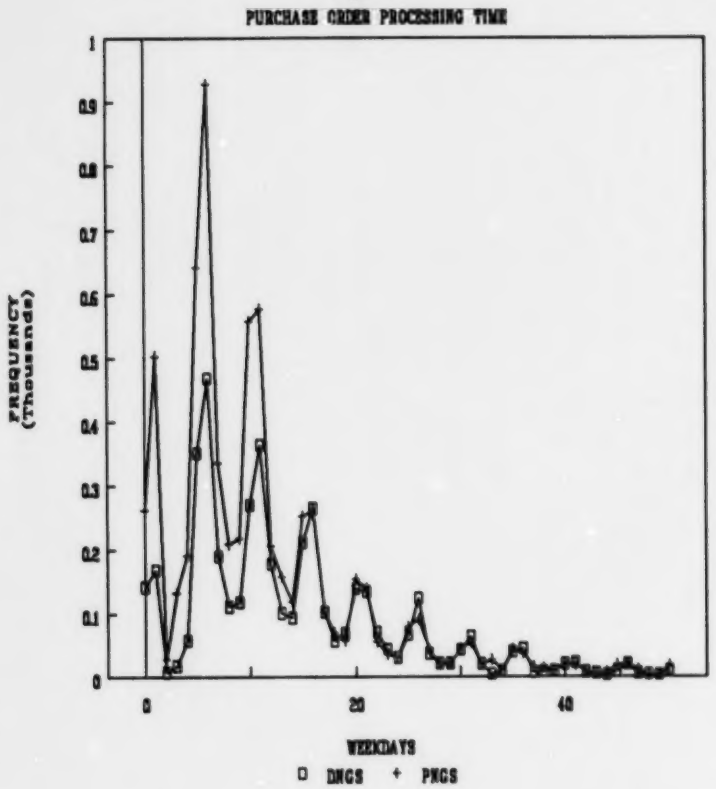
Figure 2



STATION	MEAN	STD DEV	VOLUME
DNGS	8	10	8187
PNGS	9	14	9530

Note: Elapsed time between requisition setup date and requisition approval date.

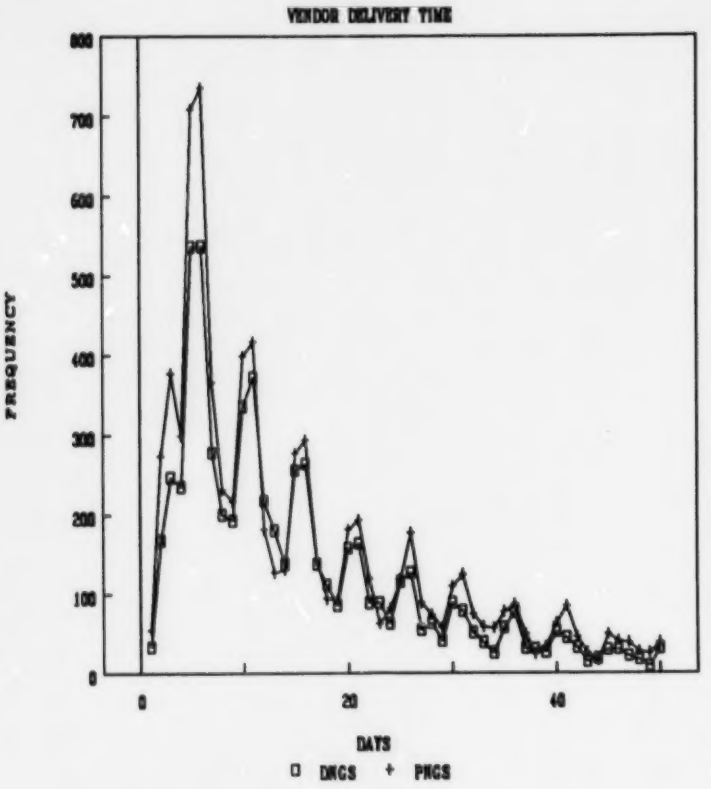
Figure 3



STATION	MEAN	STD DEV	VOLUME
DNGS	16	15	4539
PNGS	15	20	7253

Note: Elapsed time between requisition approval date and PO setup date.

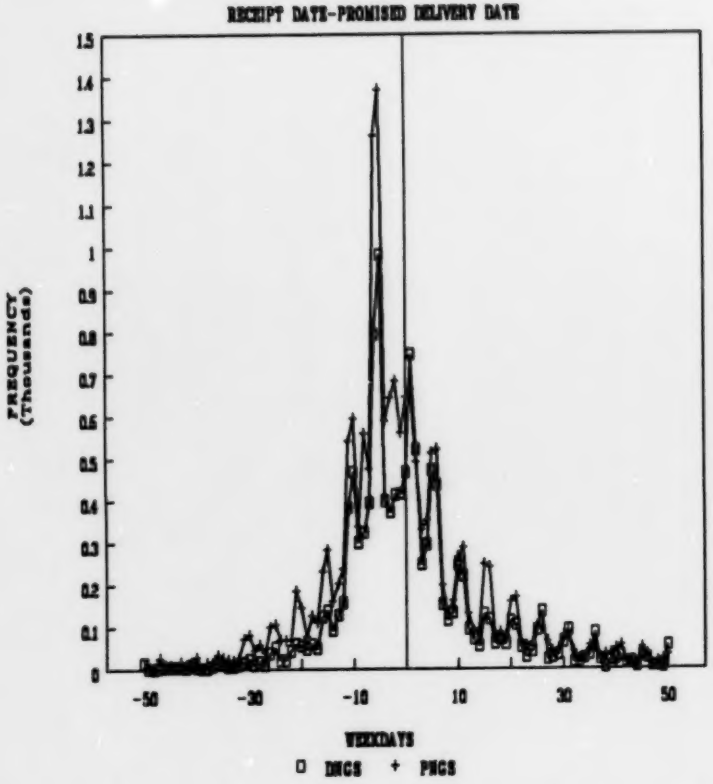
Figure 4



STATION	MEAN	STD DEV	VOLUME
DNGS	22	27	6915
PNGS	24	31	8800

Note: Elapsed time between PO setup date and material receipt date.

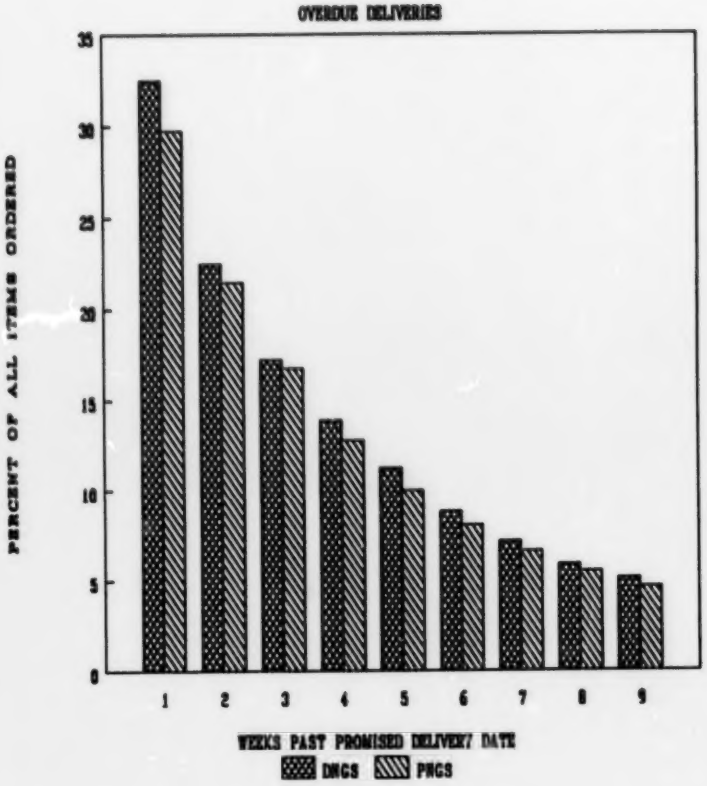
Figure 5



STATION	MEAN	STD DEV	VOLUME
DNGS	-5	29	6934
PNGS	-3	26	8808

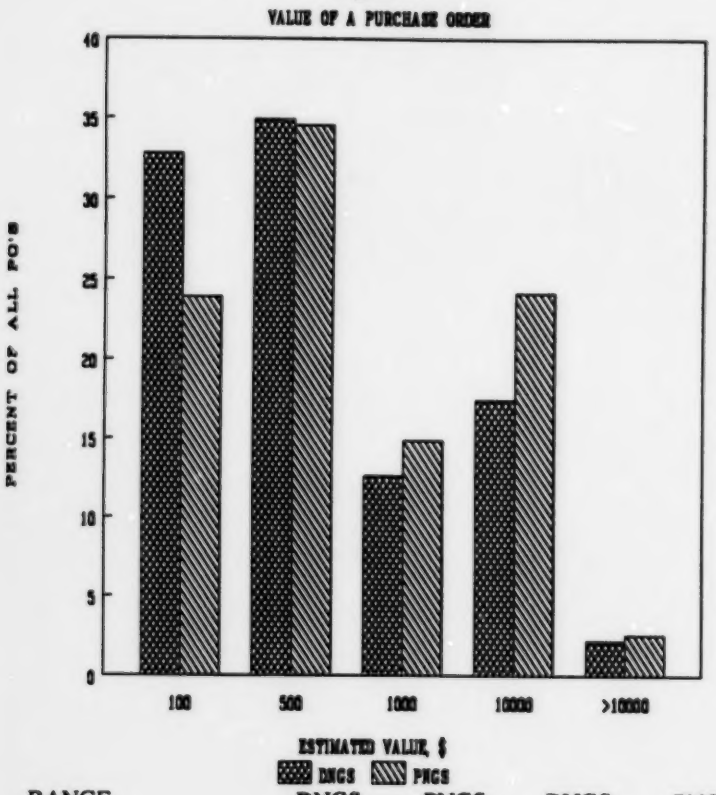
Note: negative values mean item arrives ahead of schedule

Figure 6



Examples:
30% (approx) of all ordered items are late.
23% are 2 weeks late.
5% are 9 weeks late.

Figure 7



RANGE	DNGS %	PNGS %	DNGS MEAN	PNGS MEAN
0- 99	33	24	$42	$46
100 - 499	35	35	$269	$274
500 - 999	13	15	$762	$769
1000- 9999	17	24	$2,932	$3,112
>10000	2	2	$29,156	$32,377

Figure 8

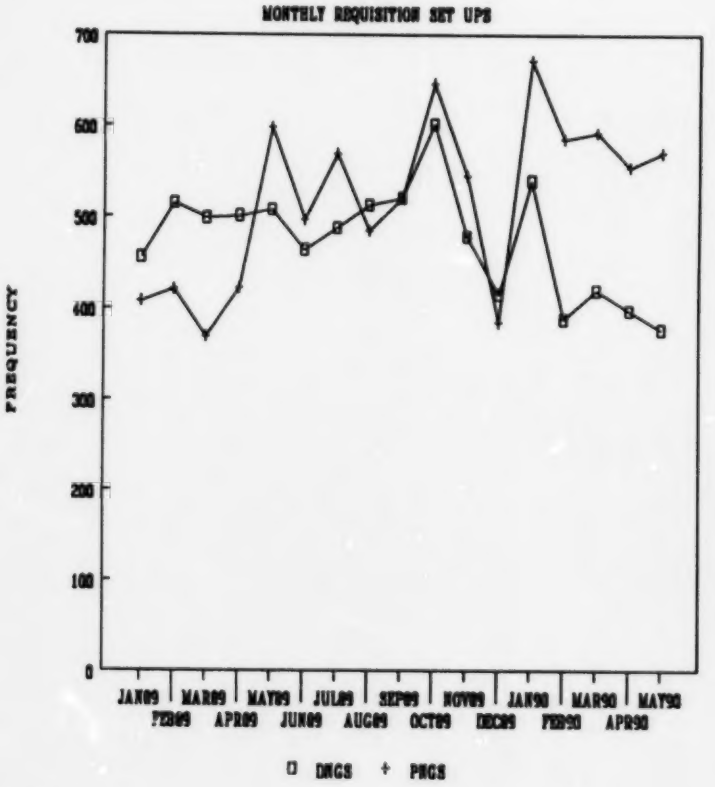


Figure 9

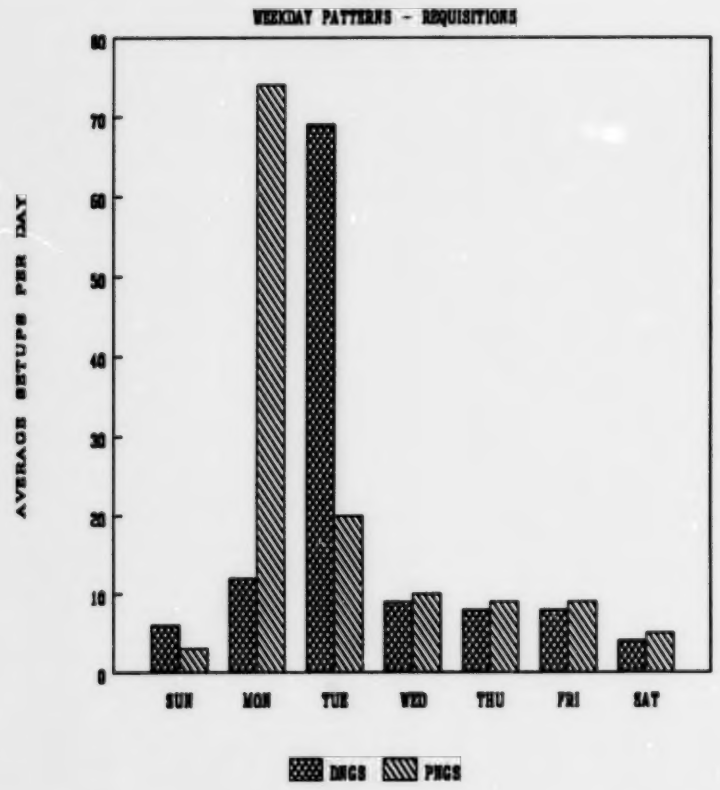


Figure 10